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OPERATING SYSTEM INDEPENDENT  
METHOD AND APPARATUS FOR TRANSPORTING  
VOICE-OVER-NETWORK DATA

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FIELD OF THE INVENTION

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The invention relates generally to methods and apparatus of transporting audio and video data. More particularly, the invention relates to systems for receiving, routing and administering audio and video data in an access server.

BACKGROUND OF THE INVENTION

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IN 5A' <sup>A'</sup> Over the past several years access servers (also referred to as communication servers or terminal servers) have been used to receive data communications and to route data from remote locations onto networks such as the Internet. For example, Internet Server Providers (ISPs) typically use access servers to administer data communications from ISP subscribers. In such implementations, the ISP typically configures one or more access servers in connection with modems, which are connected to phone lines. ISP customers, who maintain their own computers with modems, establish a connection to the ISP by placing an ordinary telephone call from

their home modem to the ISP modem. The ISP modem provides data to the access server, which typically authenticates the user and facilitates a connection from the users PC to the Internet across the modem-to-modem telephone connection. Such systems may also be used to access, for example, corporate intranets or the like.

Recent advances in access server hardware<sup>has</sup> allowed the access server to support not only modem connections, but also fax, video conference, voice, multimedia, Asynchronous Transfer Mode (ATM), frame relay, and other types of connections. Such systems frequently include data communications processors such as the Any Port Products available from Conexant Systems of Newport Beach, California.

It is typically relatively easy to build administration systems for modem connections because many popular operating systems include modem control functionality. The Windows NT operating system available from the Microsoft Corporation of Redmond, Washington, for example, includes the Telephony Application Programming Interface (TAPI), which includes specific interface calls for interacting between computer applications running on the operating system and a modem. Similarly, Linux and other versions of UNIX typically include device drivers or Application Programming Interfaces (APIs) for interacting with modems. Such functionality is not, however, generally provided for non-modem telephone connections and the like. Thus, it is more difficult to create applications that make use of the voice functionality included with access server hardware, since such functionality is not automatically addressable within the operating system.

One solution to this problem is to incorporate support for voice services within the operating system itself. Incorporating direct operating system support is typically quite difficult, however, because operating systems are generally created by entities other than those who create access servers and access server components. Most conventional operating systems therefore do not support the wide range of access servers and access server components that are available. Moreover, operating system solutions tend to be based upon proprietary protocols, APIs or hardware, and they are frequently slow to react to changes in access servers or access server components.

Another option is to develop a device driver that is unique for the particular access server or access server components utilized. Again, however, this approach provides a proprietary solution that is unique to the particular application or hardware device included. Such systems are slow to incorporate new functionality in operating systems or hardware, and moreover, they do not facilitate direct addressability from the external host. Direct accessibility is particularly desirable in environments with distributed gateways for routing voice and data communications. Hence, <sup>with</sup> the "gateway decomposition" schemes currently pursued many systems providers typically require proprietary device drivers or APIs for interacting with particular hardware.

Although voice-over-network solutions such as those described above are presently in existence, numerous problems remain with universal compatibility and external administration. It is therefore desired to create a system for providing voice services over data networks (such as the Internet) that is portable across different operating systems and types of access hardware. It is also desired to create a system that is usable with distributed gateways.

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## BRIEF DESCRIPTION OF THE DRAWING FIGURE

The above and other features and advantages of the present invention are hereinafter described in the following detailed description of illustrative embodiments to be read in conjunction with the accompanying drawing figures, wherein like reference numerals are used to identify the same or similar parts in the similar views, and:

Figure 1 is a block diagram of an exemplary embodiment of an access server system;

Figure 2 is a block diagram of a second exemplary embodiment of an access server system;

Figure 3 is a block diagram of an exemplary voice module; and

Figure 4 is a block diagram of an exemplary communications system.

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## DETAILED DESCRIPTION OF PREFERRED EXEMPLARY EMBODIMENTS

The present invention may be described herein in terms of functional block components and various processing steps. It should be appreciated that such functional blocks may be realized by any number of hardware and/or software components configured to perform the specified functions. For example, the present invention may employ various integrated circuit components, e.g., memory elements, digital signal processing elements, logic elements, look-up tables, and the like, which may carry out a variety of functions under the control of one or more microprocessors or other control devices. Further, it should be noted that the present invention may employ any number of conventional techniques for data transmission, signaling, data processing, network control, application development, and the like. Such general techniques are not described in detail herein.

To simplify the description of the exemplary embodiments, the invention is frequently described as pertaining to a system of providing voice-over network functionality. It will be appreciated, however, that many applications of the present invention could be formulated. For example, the present invention could be used to transport fax data, motion picture data, closed circuit video information, multimedia content, photographic, stereoscopic, holographic or any other form of moving video, still images, data or other information. Similarly, although the invention is frequently described herein as being implemented with TCP/IP communications protocols, it will be readily understood that the invention could also be implemented using IPX, Appletalk, IP-3, OSI or any number of existing or future protocols.

It should be appreciated that the particular implementations shown and described herein are illustrative of the invention and its best mode and are not intended to otherwise limit the scope of the present invention in any way. Indeed, for the sake of brevity, conventional data networking, application development and other functional aspects of the systems (and components of the individual operating components of the systems) may not be described in detail herein. Furthermore, the connecting lines shown in the various figures contained herein are intended to represent exemplary functional relationships and/or physical couplings between the various elements. It should be noted that many alternative or additional functional relationships or physical connections may be present in a practical access server system.

With reference to Figure 1, an access server system 100 suitable for ISDN or modem communications suitably includes a communications interface 104, access hardware 120, and a computer host 140. The communications interface 104 is any interface device that suitably receives call information from a network 102 such as the public switched telephone network (PSTN) and provides the call information via a bus 106 to an access device. The access device may be implemented, for example, as access hardware 120, as a modem (not shown), or as an ISDN modem 114. In various embodiments of the invention, communications interface 104 is a T1 interface, a modem, or another form of communications service unit (CSU).

Bus 106 is any form of connection device such as an ethernet, token ring, computer bus, or the like that is capable of transferring data from interface 104 to



access hardware 120. In various embodiments, bus 106 is a time-division multiplexing (TDM) bus. In such embodiments, various forms of digital data such as high-level data link control (HDLC) protocol information and pulse code modulation (PCM) data are suitably shared by bus 106. In the exemplary embodiment shown in Figure 1, bus 106 provides HDLC data to ISDN modem 114 and to an ISDN module 118 via interfaces 112 and 108, respectively. Similarly, bus 106 provides PCM data to a modem module 116 via an interface 110.

Access hardware 120 is any device that includes hardware and/or software controls for interfacing and processing data from remote locations. In various embodiments, access hardware 120 includes a semiconductor device such as one or more of the Any Port processors available from Conexant Systems, Inc. of Newport Beach, California. Access hardware 120 suitably includes modules for handling various types of data connections. Each module includes programming (such as hardware, software or firmware programming) that implements a particular type of data connection. Modules 116 and 118 in Figure 1, for example, correspond to modem and ISDN connections, respectively. Of course, it will be recognized that the modules discussed herein are not necessarily physically separate, but rather are logical constructs that aid in understanding. Other modules (not shown) may include voice, asynchronous transfer mode (ATM), frame relay, internet protocol (IP), fax, wireless and the like.

Communications may be suitably controlled by an application program 134 running on host 140. Exemplary computer applications include Remote Access Server

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(RAS) available from the Microsoft Corporation of Redmond, Washington or the pppd ("PPP daemon") included with various versions of the LINUX or UNIX operating systems. In such embodiments, application program 134 suitably receives requests for network services, responds to such requests by establishing connections, and assigns a network address (such as an IP address) to the connection established. Some embodiments of application program 134 further provide authentication or other security services. Of course, it will be understood that application program 134 may be any suitable communications server or controller program, and that the particular functionality and implementation of application program 134 will vary from embodiment to embodiment.

Host 140 is any form of computer such as a personal computer, a minicomputer, a mainframe or a specialized computer such as are available from vendors such as Cisco Systems of San Jose, California. It will be understood that the invention may be implemented in any form of hardware or software environment. In various exemplary embodiments, host 140 suitably runs an operating system 138 such as Windows 95, 2000, or NT available from the Microsoft Corporation of Redmond, Washington. In alternate embodiments, host 140 runs one of the many versions of the LINUX or UNIX operating systems available from vendors such as Hewlett Packard of Palo Alto, California, IBM Corp. of Armonk, New York, or Sun Microsystems of Mountain View California.

Operating system 138 suitably administers interactions between application program 134 and hardware coupled to host 140. For example, host 140 may include a

network interface 124 to a data network 126 such as the Internet, a corporate intranet, or another data network. Similarly, host 140 may include a device driver 122 that handles instructions and data transfers between application program 134 and access hardware 120. Such a device driver is typically related to the particular form of access hardware 120 utilized and will vary from implementation to implementation.

Applications such as application program 134 running on a host frequently interact with device drivers through an intermediate application programming interface (API) that provides a particular type of functionality depending upon the particular device driver. <sup>API</sup>Interface 136, for example, may be a telephony application interface (TAPI) such as TAPI 2.1 included with Microsoft Windows NT version 4.0. Telephony API 136 suitably implements many common functions required by application program 134 related to telephony such as modem controls, ISDN controls, and the like. To control a modem via application 134, for example, a programmer suitably includes computer instructions in application 134 that interact via interface 146 with telephony API 136 to control device driver 122, which in turn interacts with access hardware 120 and/or ISDN device 114.

Similarly, application program 134 interacts with a network interface 124 via network API 130 such as, for example, the NDIS 4.2 API provided with the Microsoft Windows NT operating system. Various embodiments of the network API 130 suitably include a protocol stack 132 that implements a particular suite of communications protocols such as TCP/IP, IPX, or the like. Applications 134 do not typically interact directly with network interface 124, ~~then~~, but rather include calls to network API 130 via

API  
a interface 144. Network interface 130 then suitably formats data packets in accord with  
a a protocol suite 132 and provides the packets to <sup>network</sup> interface 124 for transmission on  
network 126.

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AB  
5 As described above, application program 134 interacts with access hardware  
120 and network interface 124 via device drivers 122 and 124 and via APIs 136 and  
130, respectively. An illustrative example will show how the various elements of an  
exemplary embodiment work together to implement an access server system 100.  
When a call is received at telephony interface 104, for example, PCM data is suitably  
transmitted via bus 106 to the access hardware 120. A processor in access hardware  
10 120 recognizes the incoming call as a modem call, for example, and modem module  
116 places a request to an administering application (which may be application program  
134) to create a modem session with the <sup>access server system 100</sup> server 100. Modem module 116 sends a  
request for a new connection via device driver 122, which forwards the request to  
application program 134 through telephony API 136. The application program 134  
15 receives the request and administers the new session with the access hardware 120,  
again by sending commands and gathering data via telephony API 136.

In a common access server for use in providing Internet access, for example,  
application program 134 prompts the user to enter an authorization credential such as a  
userid/password pair. Authentication information (which is typically in point-to-point  
20 protocol (PPP) format) is entered by the user and suitably passed via device driver 122  
to a PPP handler 128 associated with network API 130 for authentication. If  
authentication is successful, application program 134 proceeds to create a virtual

connection 148 between module 116 and the network interface 124 such that the remote user is allowed to access network 126. Various embodiments of application program 134 suitably allow multiple connections through access hardware 120, and each connection may be individually addressable through, for example, conventional socket programming techniques. In such embodiments, each connection is represented to application program 134 as an individually-addressable port on access hardware 120, each port having its own network address (such as an IP address). Because application program 134 assigns each port a unique network address, the port itself is addressable by hosts on network 126. Thus, a remote user is provided with direct, addressable access to network 126.

As noted above, exemplary embodiments of telephony API 136 contain adequate controls for interacting with modems and modem modules such as module 116 on access hardware 120. As such, modem connections are relatively easy to implement in <sup>access server system 100</sup> ~~access server 100~~. Telephony API 136 does not, however, typically contain controls for accessing voice modules in access hardware 120.

Referring now to Figure 2, an access server system 200 for use in administering voice-over-network connections suitably includes access hardware 220 with a voice module 202. As described above, access hardware 220 may be any device that includes hardware and/or software controls for interfacing and processing data from remote locations such as one or more Any Port processors available from Conexant Systems Inc. of Newport Beach, California. Access hardware 220 may receive voice, ISDN, modem, and other data calls from interface 104 via bus 106, as described above.

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Access hardware 220 communicates with host computer 140 through device

driver 222, which is similar to device driver 122 described above but includes added

Device driver

support for voice module 202. <sup>Driver</sup> 222 provides an interface between access hardware 220 and host 140 through, for example, conventional interface techniques.

5 Although Figure 2 shows device driver 222 as part of host 140, it should be noted that device driver 222 functionality may be suitably implemented as software on host 140 or in hardware, software or firmware of access hardware 220. Alternatively, device driver 222 can be implemented as any combination of hardware, software and firmware on access hardware 220 and/or host 140. Various embodiments of the invention  
10 implement device driver 222 as a Windows NT miniport or as a LINUX or UNIX device driver, although of course any suitable hardware or software interface could be used.

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In various embodiments of the invention, voice module 202 is represented to host 140 as a modem connection. Various embodiments implement the modem-like connection differently, but exemplary techniques include formulating a modem  
15 connection in device driver 222 such that operating system 138 "thinks" that data sessions with voice module 202 are modem connections instead of voice connections.

To this end, device driver 222 suitably presents voice module 202 to host 140 as a modem port. In various embodiments of the invention, the modem connection is

established by passing an electronic message to telephony API 136 with modem

20 parameters instead of conventional voice parameters. These parameters are dictated by the particular telephony API, and vary from implementation to implementation.

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When a connection is initiated in this manner, telephony API <sup>136</sup> suitably creates a

connection with device driver 222 that emulates a virtual modem connection 230 between voice module 202 and telephony API 136.

Because the voice connection is presented to the host as a modem connection, the modem functionality implemented in telephony API 136 may be suitably used to send commands and to retrieve data between voice-enabled application 134 and voice module 202 through virtual connection 230. In various embodiments of the invention, telephony API notifies application program 134 that a modem connection is received, and application program 134 may then create virtual connection 148 between voice module 202 and network interface 124, for example as described above. Connection 148 may be created, for example, through conventional programming techniques utilizing the standard telephony API 136.

With continued reference to Figure 2, <sup>server</sup>voice access system 200 suitably administers voice calls by providing a convenient interface between application program 134 and voice module 202 such that voice data is effectively transported to network 126. When voice service is initiated (for example at startup, or as directed by application program 134, or in response to a voice call received from network 102), module 202 establishes a virtual <sup>voice</sup> modem connection 230 through driver 222 and operating system 138 to application program 134. Because the virtual connection 230 acts as a modem connection, application program 134 communicates to device driver 222 through conventional telephony API calls. These calls are suitably addressed to <sup>device</sup>driver 222, which converts instructions and data to a format that is understood by <sup>voice</sup>module 202 as necessary. In this manner, application program 134 suitably interacts

via telephony API 136 and network API 130 to create virtual connection 148 between access hardware 220 and network 126 using, for example, techniques similar to those employed to create the virtual modem connections described above. In various embodiments, application program 134 assigns a network address (such as an IP address) to the connection such that virtual connection 148 (and thus the port on access server 220 corresponding to voice module 202) is addressable by entities on network 126. With the virtual connection established, voice communications are suitably routed between server 220 and network 126. Thus, a standard computer application 134 such as RAS or pppd can be used in conjunction with a standard telephony API 136 to implement an access server system 200 that provides voice functionality.

In various embodiments of the invention, voice module 202 suitably encapsulates voice data into a protocol frame such as a PPP header that can be transmitted to a local or remote server. Alternatively, commands from a local or remote server may be suitably encapsulated in a network frame such as a PPP frame. Voice module 202 suitably extracts command information from the network frame and executes the commands as necessary.

With reference to Figure 3, an exemplary voice module 202 suitably includes sub-modules for processing voice calls received from connection 204 to bus 106 (not shown in Figure 3). Each of the sub-modules is a logical construct that illustrates a particular process executed by access hardware 202. Layer 302 receives voice information in, for example, PCM format and decodes the data at a signaling level. As



such, layer 302 typically implements protocols such as G.165 and G.168, or any other signaling protocols required. Layer 304 administers any necessary compression or decompression of voice data, for example using the G.723, G.729, G.711 or any other compression routine. Layers 306, 308 and 310 suitably administer the real-time transport protocol (RTP), the user datagram protocol (UDP) and PPP, respectively.

RTP layer 306 packages voice samples into a known format as appropriate, and UDP layer 308 suitably encapsulates voice data in a UDP packet that can be transmitted via virtual connection 148, for example, to network 126. In various embodiments, PPP layer 310 suitably encapsulates the voice data in a PPP frame, as described above.

Again, alternate embodiments of the invention implement voice data processing in different manners using various protocols. In particular, it is not necessary to include RTP or PPP encapsulation in all embodiments of the invention. Alternatively, the point-to-point tunneling protocol (PPTP) or another protocol could be substituted for PPP or RTP.

Voice data produced at voice module 202 is provided to a destination and suitably processed as required by the particular embodiment. In various embodiments, application program 134 suitably routes voice data to a proper destination on network 126 by embedding the formatted voice data in a network frame such as a TCP/IP frame via network API 130. Various embodiments of application program 134 implement signaling and routing through calls to network API 130. Voice data may be routed directly to a destination on the network, or they may be routed to an administrative server on network 126 that handles routing, billing, etc.

With reference to Figure 4, a system implementing a so-called "gateway decomposition" scheme includes host 140 communicating with access hardware 220 and with data network 126. Voice calls are received from PSTN network 102 and routed to data network 126 through virtual connection 148 (not shown in Figure 4) as described above. Server 404 on network 126 suitably interacts with voice module 202 on access hardware 220 via the network address assigned to the virtual connection to transmit voice data to a destination host 406. Server 404 may also provide billing, routing and other functionality as required. Various voice servers 404 such as those available from various manufacturers suitably communicate with voice module 202 via network packets sent through data network 126. In exemplary embodiments the control network packets include commands that are encapsulated in PPP or other network frames, and then sent to host 140 via, for example, conventional TCP/IP addressing and delivery techniques. With momentary reference again to Figure 2, host 140 receives the control packet on interface 124 and passes the data via network API 130 as directed by application 134 and in accordance with addressing information contained in the control packet. In various embodiments, the control packet includes a reference to a particular address or socket corresponding to virtual connection 148, and the control packet is suitably formatted and provided to voice module 202 as described above. Voice module then extracts the command information from the PPP frame using layer 310 (best shown in Figure 3) and executes the command. Various commands instruct the voice module to produce a dial tone, hang up the line, provide data to a given destination, and the like. In various embodiments, voice module 202

further includes routing capability for administering multiple incoming voice calls through virtual connection 148. In this manner, many simultaneous voice connections can be produced through a single access hardware unit 220.

5 The corresponding structures, materials, acts and equivalents of all elements in the claims below are intended to include any structure, material or acts for performing the functions in combination with other claimed elements as specifically claimed. The scope of the invention should be determined by the appended claims and their legal equivalents, rather than by the examples given above.

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